Volume 36 September, 1950 *Number 9*

Lubrication

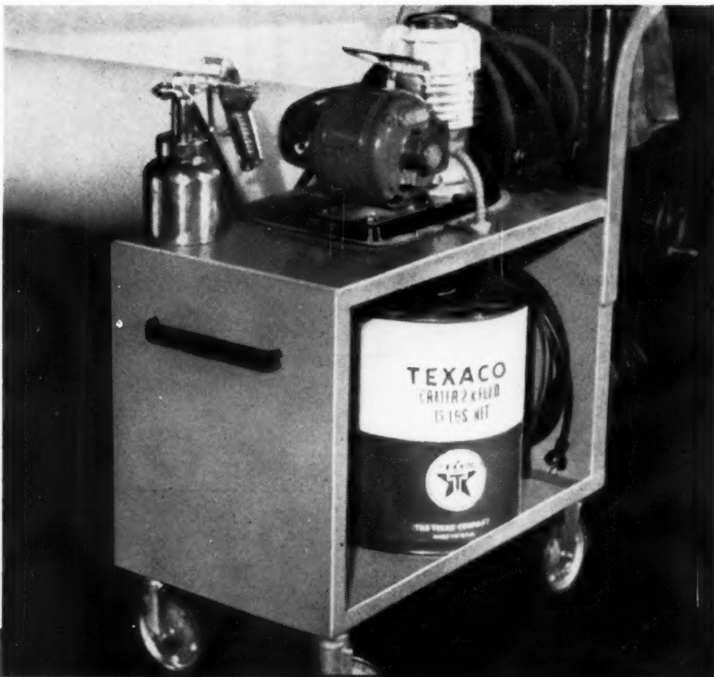
A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Grease Application Devices

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Apparatus for spraying gear lubricant as described below



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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Vol. XXXVI — September, 1950 — No. 9

Change of Address: In reporting change of address kindly give both old and new addresses.

Grease Application Devices

PRESSURE GREASE lubrication came about when some inventive genius back in the early days of the machine age hit upon the idea of threading a metal cup and screwing it onto a companion fitting through which a hole was drilled, which in turn was threaded and screwed into a bearing cap. This made it possible to fill the cup with grease, screw it onto the fitting and force the grease down to the rotating shaft.

With this humble beginning as a basis, the builders of lubricating equipment proceeded to design and perfect other ways of controlling and impelling grease to the various points of delivery. Successively the transition was in line with the following order:

1 – The hand-operated grease cup.
2 – The pressure gun.
3 – Spring type grease cups.
4 – The power driven grease lubricator.
5 – Multiple tube and floor level lubrication.
6 – Centralized pressure.

SUITABLE means for application are necessary wherever grease is to be used as a lubricant. This became obvious when transportation machinery discarded the wagon axle with the development of the automotive industry. Railroads and manufacturers also appreciated the value of grease as a lubricant for heavy duty service where the lubricating oils of that period could not be conveniently or dependably applied without shut-down.

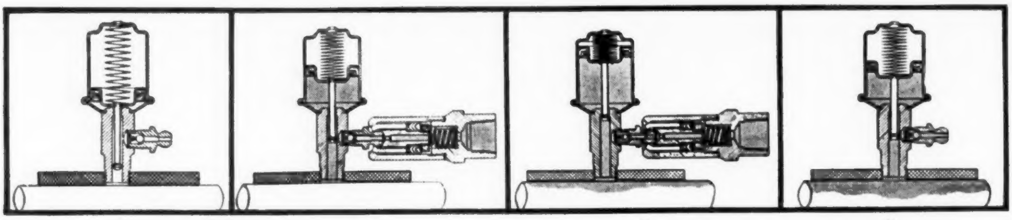
All this was developing along with the Petroleum Industry, so it was natural that study of the procedures in making mixtures of oil and soap should become a part of this development. It was appreciated that the conventional method of smearing grease onto wagon axles with a stick had to give way to a cleaner, more positive means of application. The grease cup was the first solution. From it, as the embryo in pressure lubrication, has resulted the variety of pressure grease lubrication devices which are accepted so casually today. This article tells about some of this development.

THE PRESSURE GUN

The pressure gun was one of the first improvements over the grease cup. It has since become an important adjunct in the operation of certain types of centralized pressure greasing systems. In its usage, a pressure gun may either be designed as a directly connected unit, thereby becoming an integral part of the system, or a portable hydraulic gun may be used. This device is of decided value as a general piece of plant lubricating equipment, inasmuch as it can be used quite as effectively in connection with individual lubricators as well as with a centralized system. It can furthermore be used to fill the spring type of cup with equal dependability.

SPRING TYPE GREASE CUPS

The combination of the pressure grease gun plus the spring type cup is decidedly advantageous for the lubrication of inaccessible or hazardously located bearings on many types of machinery. As a general rule, by using a

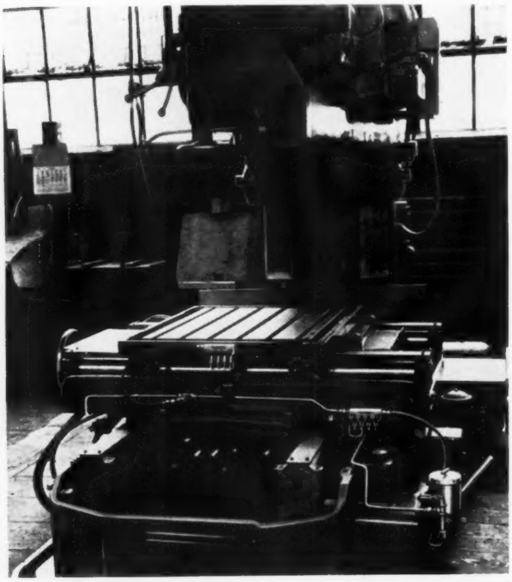


Courtesy of Stewart-Warner Corp. — Alemite Sales Div.

Figure 1 — Operation of a hydraulic spring type cup.
A. Before charging.
B. Pressure gun attached.
C. Cup now full, bearing lubricated by gun pressure.
D. Gun detached, lubricating by spring pressure.

spring of particular tension plus a suitable orifice, grease discharge can be very accurately controlled. Furthermore, the indicator with which it is usually equipped shows the amount of grease in the lubricator at any time.

Filling of such a cup is a simple and cleanly matter. It merely amounts to attaching the pressure gun to the fitting located in the base of the cup. There is no necessity for removal of the cover, as may be true with those cups which are more strictly of the hand pressure type. In consequence there is more positive assurance that the grease charge will not become contaminated through entry of dust or dirt.



Courtesy of Lincoln Engineering Company

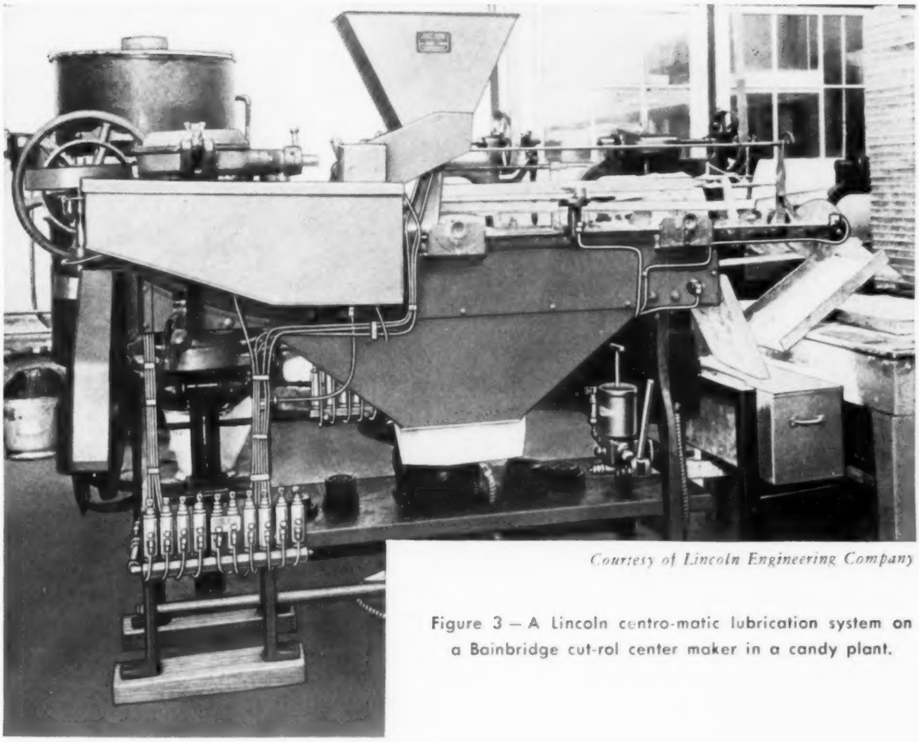
Figure 2 — A Lincoln Centro-matic lubrication system on a Cincinnati Bickford Man-au-trol. Note the 12 injectors, and pump at right.

The next step is to shoot grease into the cup until the indicator (where one is used) rises to its full height to show that the cup has been completely filled. The initial pressure for such filling may be obtained by use of compressed air, electric power, or simply hand or foot power, according to the type of gun and the pressure desired. Of course, where a relatively simple hand pressure grease gun is used, the impression may be gained that this should be classified with the hand pressure or screw-down type of cup. Hand pressure, however, as applied to a grease gun does not react directly on the bearing; it must first be converted to mechanical energy by doing work in compressing the spring in the grease cup. From this point on lubrication is automatically maintained by the mechanical action of the spring upon the adjacent plunger which bears upon the grease charge to force it through the bearing.

THE POWER DRIVEN GREASE LUBRICATOR

There are certain phases of operation, however, where grease lubrication under considerably higher pressures are required than can be attained through the average spring type of cup. Here the question of positive and complete cleaning of bearing clearance spaces and oil grooves (where included) prior to re-lubrication will be of primary importance, especially where conditions of operation may be conducive to entry and accumulation of dust, dirt or other non-lubricating foreign matter.

Automatic delivery of lubricant is, in such cases, dependent upon the pressure available. In the spring type grease cup the pressure normally is lower than where direct application of grease by



Courtesy of Lincoln Engineering Company

Figure 3 — A Lincoln centro-matic lubrication system on a Bainbridge cut-rol center maker in a candy plant.

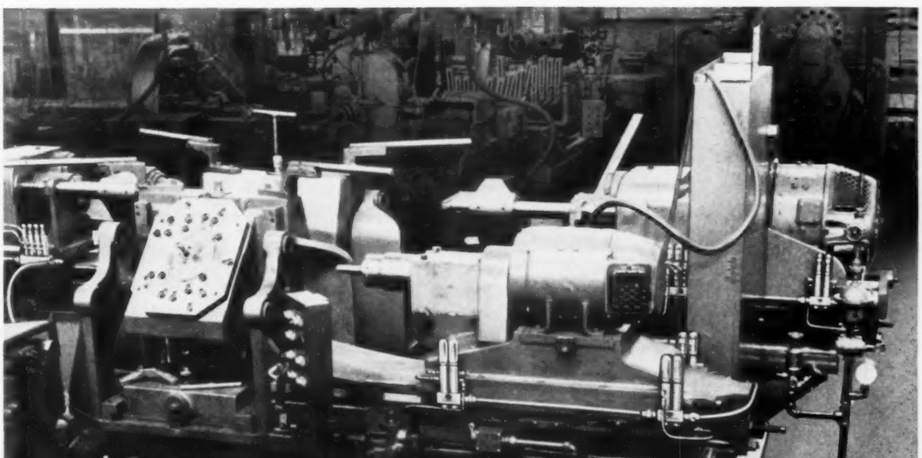


Figure 4 — The Lincoln centro-matic system on a Snyder bell housing machine. 40 injectors are used in this installation.

Courtesy of Lincoln Engineering Company

Courtesy of National Sales Inc.

Figure 5 — The National Sales Gre-Zer-Ator lubricating a corn picker.

means of a pressure gun is employed.

On the other hand, use of the pressure gun in virtually any form requires a certain amount of manual handling. The gun itself must be moved about, flexible hose must be handled, fittings must be wiped clean before attachment of the hose or gun connection, and finally the gun must be put into operation. All this requires time, care and good judgment. The latter is especially essential in determining when a bearing has been completely relubricated.

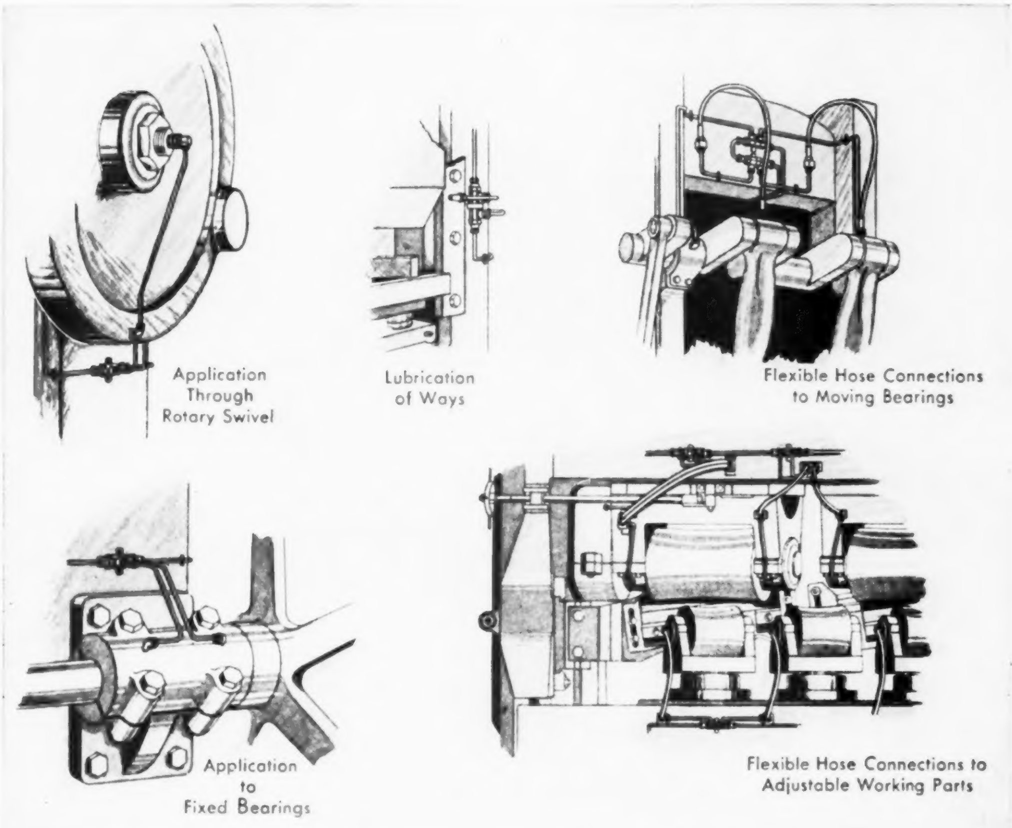
TYPES INVOLVED

Pressure lubricators have been mentioned as being of either the hand or power type. For the use of the individual machine operator the former is perhaps the most suitable device, due to its ability to operate by means of hand or foot pressure.

Grease guns of the hand pressure type will usually be capable of developing several thousand pounds pressure per square inch. They are practicable either with or without hose connections, according to the type of fitting they are designed for, or the location of the part to be lubricated.

Pressure can be applied either before or after attachment of the gun to the fitting. A frequent method of developing pressure is to force down a suitable plunger by means of a threaded stem which screws into a bushing in the head of the gun. Another type of gun involves pumping action by means of the handle and a suitable pressure retaining device.

According to the design, where pressure is to be developed before attachment of the gun to the fitting, a suitable check valve must be installed in the tip. In certain guns the act of attachment opens this valve and automatically permits lubricant to be forced in the bearing.



Courtesy of Stewart-Warner Corp. — Alemite Sales Div.

Figure 6 — Showing a number of applications of the Alemite dual progressive lubricating system.

The purpose of providing check valves is to eliminate the necessity of relieving the pressure before detaching the gun from the fitting and to enable pressure to be raised before attachment, to overcome the possibility of twisting off the fitting, which might otherwise occur. The direct or swivel jointed connection also does away with the possibility of leaks in the flexible hose. Most of the fittings in use today are of the hydraulic type, being designed to lock automatically in the end of the gun fitting. An increase in gun pressure results in a tighter connection between the gun and fitting.

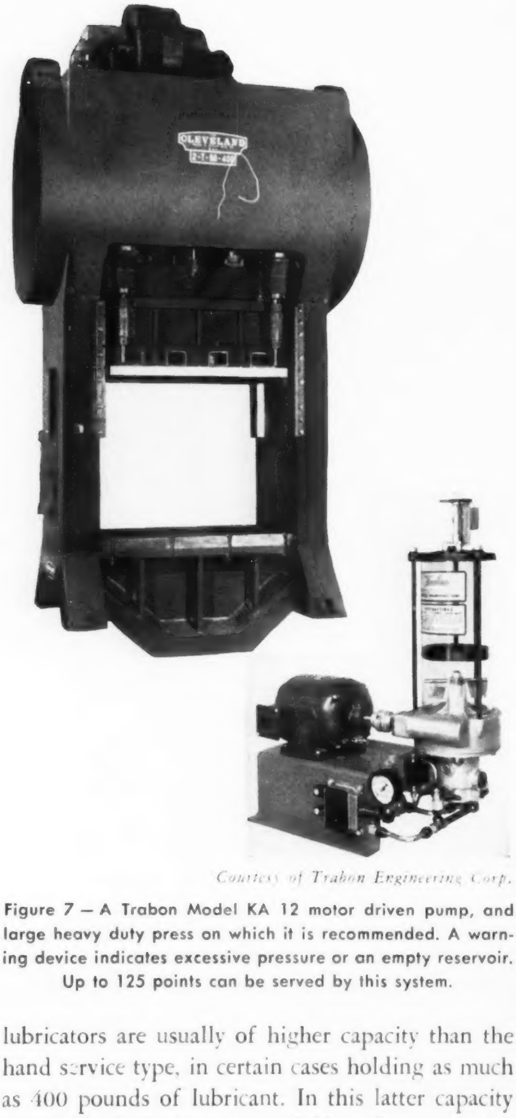
These factors are especially important where bearings are to be "started" involving the expulsion of grease which has been allowed to remain too long in the grooves or clearance spaces and consequently become gummed, caked and mixed with dirt.

In heavy duty service, however, the hand pressure gun is frequently supplanted by the mechanical or power lubricator of considerably greater grease capacity. In general, such lubricators are capable of holding 50 pounds of grease or more.

A ball or check valve at the base of some pumps automatically closes at the end of each stroke to retain all pressure that may have been built up. To insure efficient operation this check valve must, of course, be kept clean. It should, therefore, be inspected at frequent intervals. In others there is no pressure remaining. In the air-operated type there is a valve within the pump mechanism which automatically releases the pressure in the gun when not in use, to insure longer life of the hose.

In such lubricators pressures of from 1000 pounds upward are readily developed. These pressures are sufficient to effectively handle the usual grades of grease which are applicable to industrial or automotive service.

The electric or pneumatic compressor, however, has proved to be very suitable for the handling of heavier and more viscous grades of lubricants. Such



Courtesy of Trabon Engineering Corp.

Figure 7 — A Trabon Model KA 12 motor driven pump, and large heavy duty press on which it is recommended. A warning device indicates excessive pressure or an empty reservoir. Up to 125 points can be served by this system.

lubricators are usually of higher capacity than the hand service type, in certain cases holding as much as 400 pounds of lubricant. In this latter capacity a multi-lead discharge manifold is frequently installed to enable the lubrication of a number of points simultaneously. Such compressors can be either electrically driven, or designed to take their air from an adjacent compressed air line. In other respects, however, the principles of the power lubricator or compressor are much the same as those involved in the hand service type.

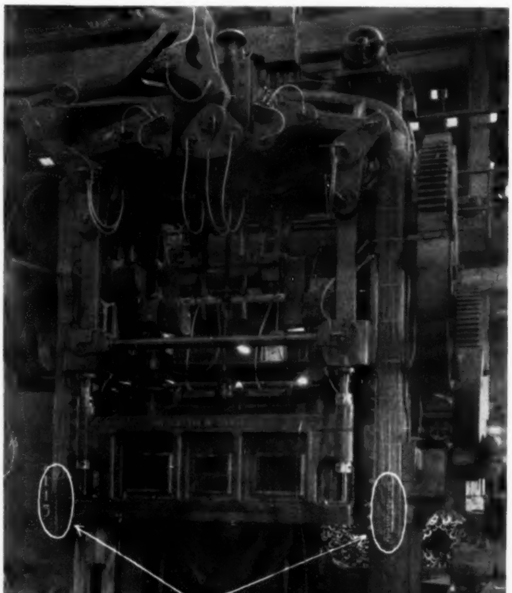
MULTIPLE TUBE AND FLOOR LEVEL LUBRICATION

This method of lubrication provides for running the grease pipes from the various bearings on a machine to a conveniently located charging panel at floor level. Thus the hazard of climbing over a machine to reach remote points is eliminated and the machine can be lubricated while it is in operation by whatever type of pressure gun or power lubricator the plant may be using. Obviously, however, since grease discharge at the bearings cannot always be seen, care is necessary to guard against possible over-lubrication and loss of grease.

CENTRALIZED PRESSURE

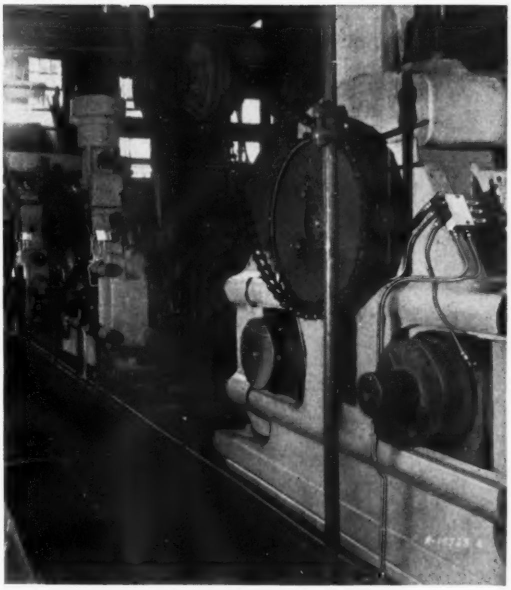
Centralized pressure grease lubrication is applicable to heavy-duty mass production machinery such as involved in the iron and steel industry and metal forming. It provides for measured lubrication.

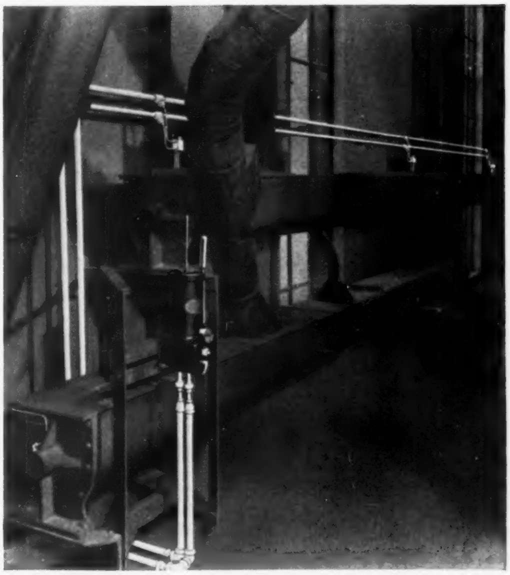
The earlier developments of pressure lubrication as applied to heavy industrial machinery were more or less confined to unit devices. The pressure grease cup had proved its adaptability to parts which were accessible. But, it was of limited capacity; furthermore, as machinery was perfected many of the parts were so located that hand-lubrication was very difficult, dangerous or even impossible. The study of means for centralized pressure grease lubrication,



Courtesy of The Farval Corp.

Figure 8 — Showing concentration of lubrication nipples for a Farval centralized lubricating system.





Courtesy of The Farval Corp.

Figure 9 and 10 — Farval centralized lubrication in productive industry. At left, installed on a sugar mill tandem, at right, serving the screw conveyors in a flour mill.

therefore, became a logical consequence. The features of any such means of lubrication include:

(a) Positive delivery of lubricant under adequate pressure to insure maintenance of a sufficient film between the bearing surfaces.

(b) Exclusion of non-lubricating foreign matter.

(c) The minimum of hazard in handling or filling.

(d) Decided economy of lubricants and,

(e) Simple to operate.

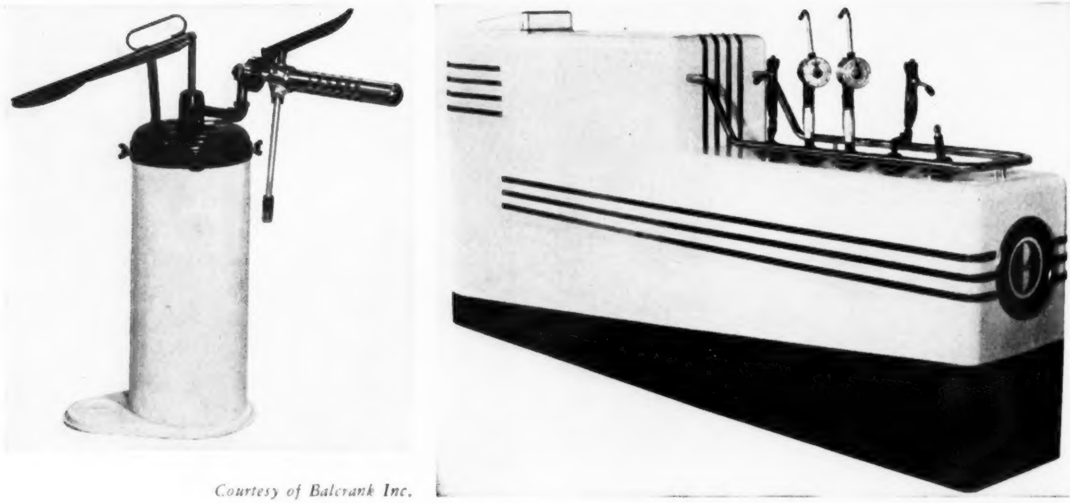
The adaptability of centralized control was pioneered by the iron and steel industry. When roll neck bearings, table rolls, and the wide variety of other heavy duty bearings were largely exposed, heavy greases were used; these products were best able to remain adjacent to the parts to be lubricated with consequently low loss. At best, however, this type of lubrication was inadequate. Furthermore, dripping of lubricant introduced a personal hazard which was contrary to all ideals of safety.

Centralized pressure grease lubrication gained in popularity as steel mill rolling machinery was improved and designed to run at higher speeds, it enabled control of greases and their delivery to the various points of application. Improvement in bearing closures with marked extension of the use of roller bearings and the use of lighter bodied greases also developed. Both increase operating economies, the former from the viewpoint of reducing leakage and improving working conditions, the latter by reducing the amount of power required for mill operation.

Collective lubrication through manifold equipment as practiced today, assures of positive and uniform distribution of the lubricant. Furthermore, direct power systems are well suited to service where comparatively high application pressures are desirable. Positive and complete cleaning of bearing grooves and clearance spaces at periodic intervals is of primary importance, especially where conditions of operation may result in accumulation of dust, dirt or other non-lubricating foreign matter.

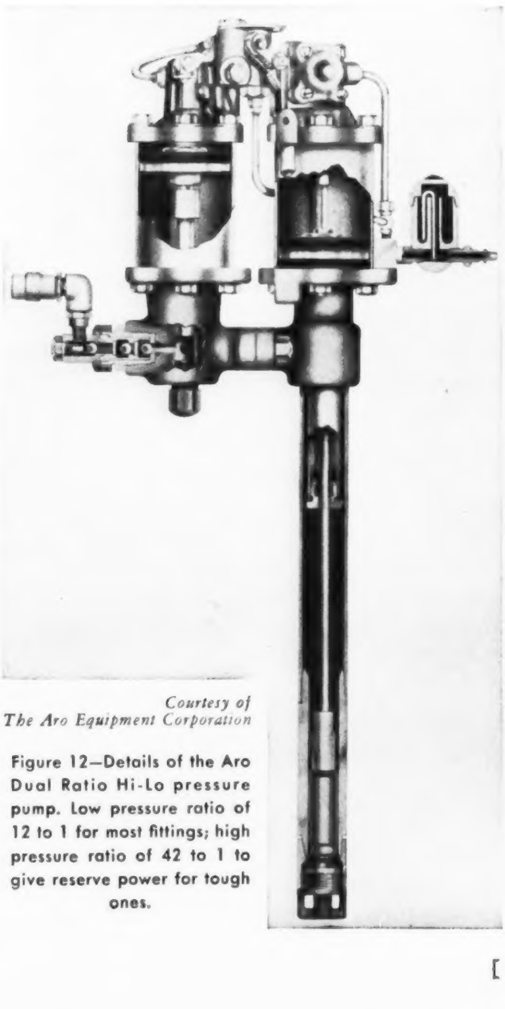
Where positive piston displacement types of metering valves are employed at each point to be lubricated, hydraulic power has been found to be especially adaptable, as a means of valve control. In such a system either one or two lubricant supply lines can be connected to each valve according to the type of system selected.

Where dual lines are employed, the pressure on the lubricant developed by the central pumping unit is directed alternately into first one and then the other of the two supply lines. The differential of pressure on the pistons in the lubricant measuring



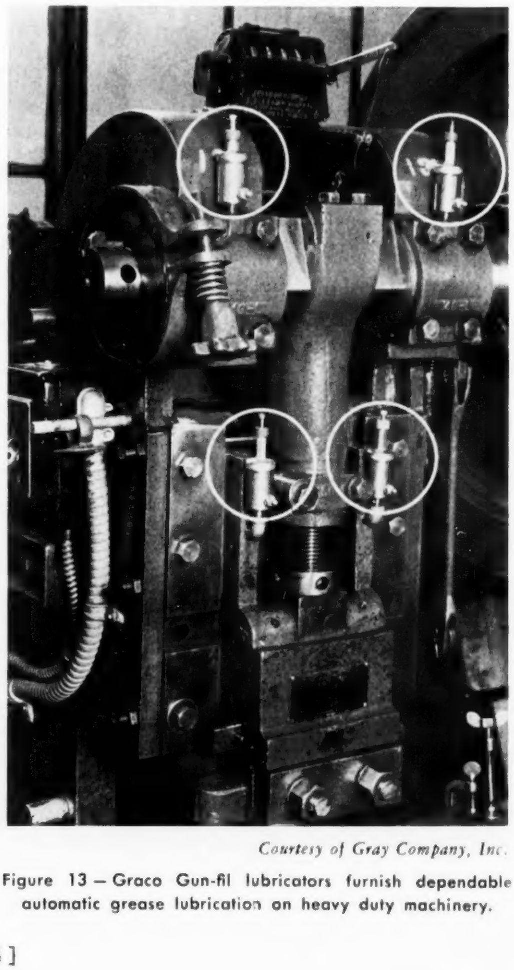
Courtesy of Balcrank Inc.

Figure 11 — The Balcrank Lubette—Model B, and Handy Andy portable lubricator with high pressure grease gun.



Courtesy of The Aro Equipment Corporation

Figure 12—Details of the Aro Dual Ratio Hi-Lo pressure pump. Low pressure ratio of 12 to 1 for most fittings; high pressure ratio of 42 to 1 to give reserve power for tough ones.



Courtesy of Gray Company, Inc.

Figure 13 — Graco Gun-fil lubricators furnish dependable automatic grease lubrication on heavy duty machinery.

valves causes them to move and discharge a predetermined quantity of lubricant to the bearings.

PRESSURE MUST BE USED JUDICIOUSLY

The value of pressure in forcing out old grease and dirt from certain types of bearings has been definitely proved. Judgment is necessary, however, in determining when this has been completely accomplished and when to shut off the pressure and cease forcing in new grease. If properly done, pressure grease lubrication is decidedly economical. If the operator is careless, however, unobservant, or continues to apply lubricant beyond the necessary extent, grease will not only be wasted but also a sloppy condition around bearings will develop. A slight bulge of fresh grease at a sleeve-type bearing end will usually indicate that complete re-lubrication has been accomplished with the least waste of product.

The amount of grease delivered to a roller bearing can be controlled by judicious installation of a suitable vent in the upper part of the housing which enables efflux of grease after a certain amount has been charged. Concentration of pressure gun fittings at a central panel or point of control aids also in reducing hazard and the labor essential to lubrication.

Certain of the systems involving electric power or compressed air are designed to eliminate the necessity for springs, check valves or restricted port openings. The constant pressure which is exerted upon the lubricant prevents the development of air pockets which might interrupt positive flow.

MEASURED LUBRICATION

For certain types of mechanisms, notably ball and roller bearings, lubrication by fairly definitely known quantities of grease is desirable. Normally with unit bearings, i. e. those which are lubricated individually by hand or pressure grease guns, if the bearings are charged from one-quarter to one-half full there will be less chance of the grease working out past the seals if expansion or air entrainment occurs. Too much grease in a bearing due to over-enthusiastic use of a pressure gun, for example, is a prevalent cause of leakage. Some types of bearing seals can be impaired if this is continued.

Carefully planned schedules for re-lubrication, with due regard for the service, is good insurance against over-lubrication. Instruction of plant personnel responsible for lubrication also is helpful especially if they are acquainted with the design of the various types of ball or roller bearings on their machinery and are instructed as to the relative sealing ability of conventional bearing seals. A look at the inner workings of any such bearings will indicate that there is just so much space available for lubricant unless the bearing is on a circulating system. If it is over-filled even though the seals are tight enough to prevent leakage, the internal friction within some type of grease can cause marked increase in operating temperatures.

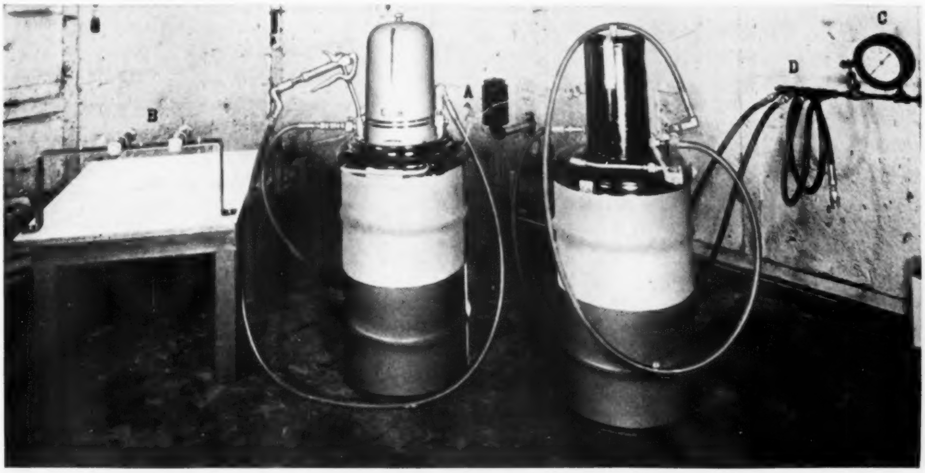


Figure 14 — The air operated pump assembly.

Greases of calcium or lime soap base are not designed for temperatures much above 150° F., so if these temperatures are approached and conventional cup-type grease is involved, the water bond will be slowly evaporated to result in separation of the oil from the soap. It is all very well to say that ball and roller bearings should be lubricated with greases of sodium-calcium base or some other base more resistant to temperature than calcium (lime) alone, but many operators will continue to use the latter, notwithstanding, because they are cheaper.

Fully realizing the possibilities of trouble from over-lubrication of grease lubricated anti-friction bearings, builders of lubrication devices as well as lubrication engineers in industry have given much thought to the subject of measured lubrication. Some of the ideas are of definite interest.

(a) A pressure gun is available with data etched on the barrel showing fraction of an ounce of grease in terms of strokes of the gun, i. e.

1/8 ounce for 6 strokes
1/4 ounce for 12 strokes
1/2 ounce for 24 strokes

(b) The more elaborate centralized pressure systems which provide for metering grease in measured amounts during a lubrication cycle. Such systems are operated from one central point; the lubrication cycles can be spaced to suit the requirements of the bearings and each receives a pre-determined amount of grease at every cycle.

(c) Venting a bearing with the vent hole located near the top of the housing. The grease content of a vented bearing is controlled by re-lubricating while the shaft is turning. When the pressure on the grease in the bearing is built up sufficiently, grease is forced out of the vent hole. Depending on

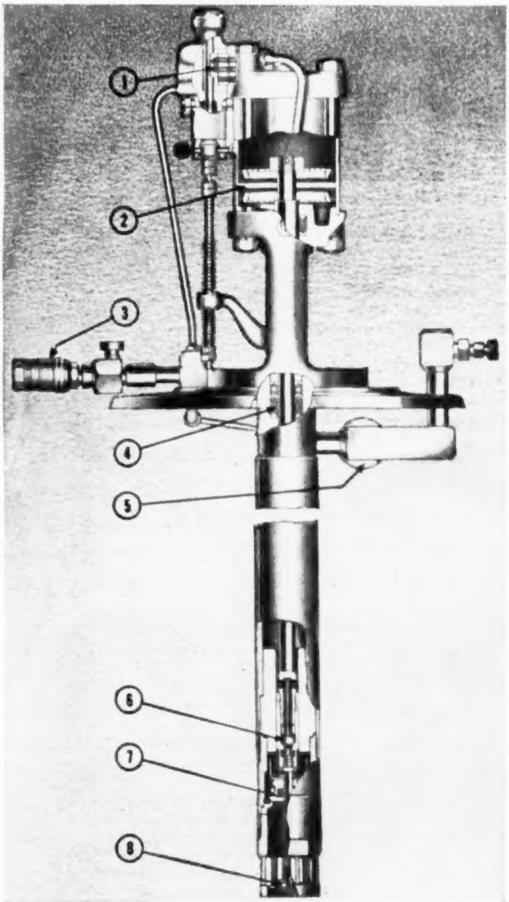


Figure 15 — Details of the Alemite air-operated pump mechanism.

1. Air valve.
2. Air motor.
3. Quick detachable air coupling.
4. Dual series high pressure packing.
5. Hose miser.
6. High pressure piston and cylinder.
7. Primer or foot valve.
8. Primer.

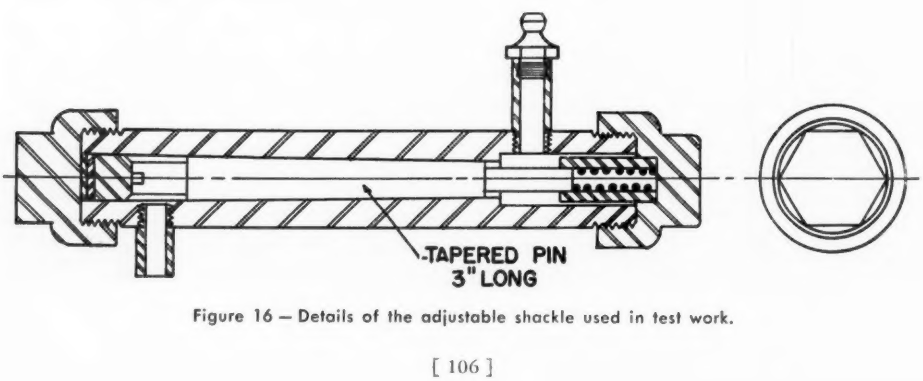
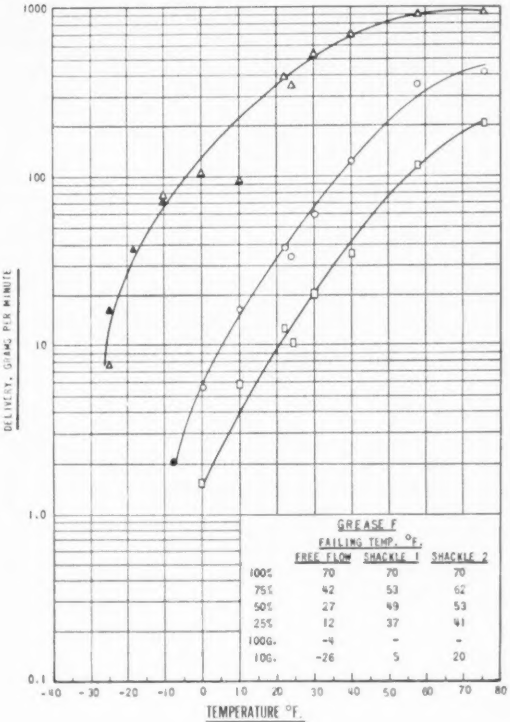


Figure 16 — Details of the adjustable shackle used in test work.



GREASE F FAILING TEMP. °F.	FREE FLOW	SHACKLE 1	SHACKLE 2
100%	70	70	70
75%	42	53	62
50%	27	49	53
25%	12	37	41
100G.	-4	-	-
10G.	-26	5	20

Figure 17

Code: △ – Indicates free flow.
○ – Indicates flow through "loose" shackle.
□ – Indicates flow through tight shackle.

the location of the latter above the center-line, the bearing can be charged to about two-thirds its capacity without danger of forcing the seals.

(d) Vented grease fittings are designed to accomplish this same objective, the fittings being built with a pressure relief which functions when the back pressure developed by the grease in the bearing is sufficiently built up.

PUMPABILITY CHARACTERISTICS

In the type of service involved at the time the compression grease cup was developed, calcium soap cup greases of around an NLGI No. 1 or 2 consistency were most widely used. In those days machinery so lubricated was subjected to less severe service than prevails today and rode largely on friction type sleeve bearings. Furthermore, if operating conditions were intensive, that is, involving unusually high temperatures, folks were not too concerned if the grease separated. The procedure was to lubricate more frequently and force out any separated soap with a fresh charge of grease from the cup. If the grease separated in the cup, the bearing clearances were so generous that forcing a slug of soap through them did no harm.

Today, with the adoption of smaller bearing clearances and the perfection of high pressure units and centralized pressure greasing systems involving long-wall diameter lines the so-called "pumpability" characteristic of greases is becoming more and more important.

Pumpability of a grease is that property which indicates how readily it can be handled in a grease

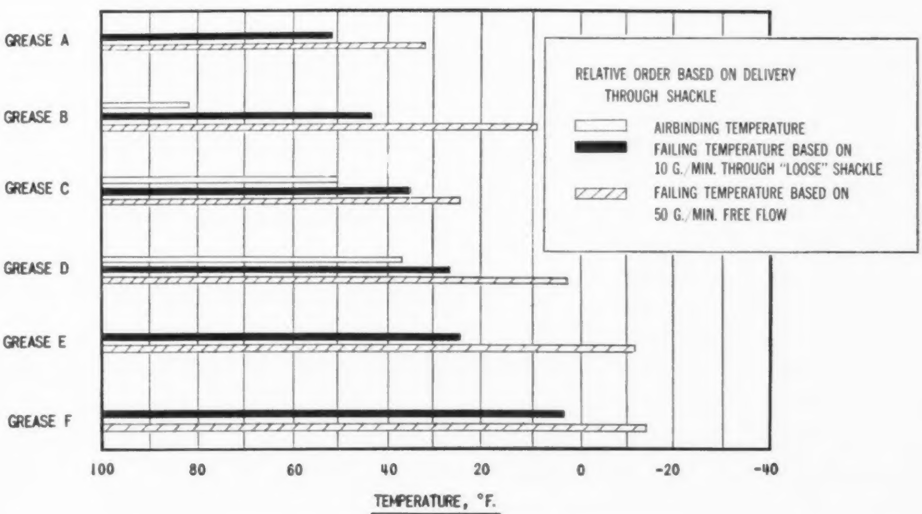


Figure 18 – Bar-graph showing failing temperatures.

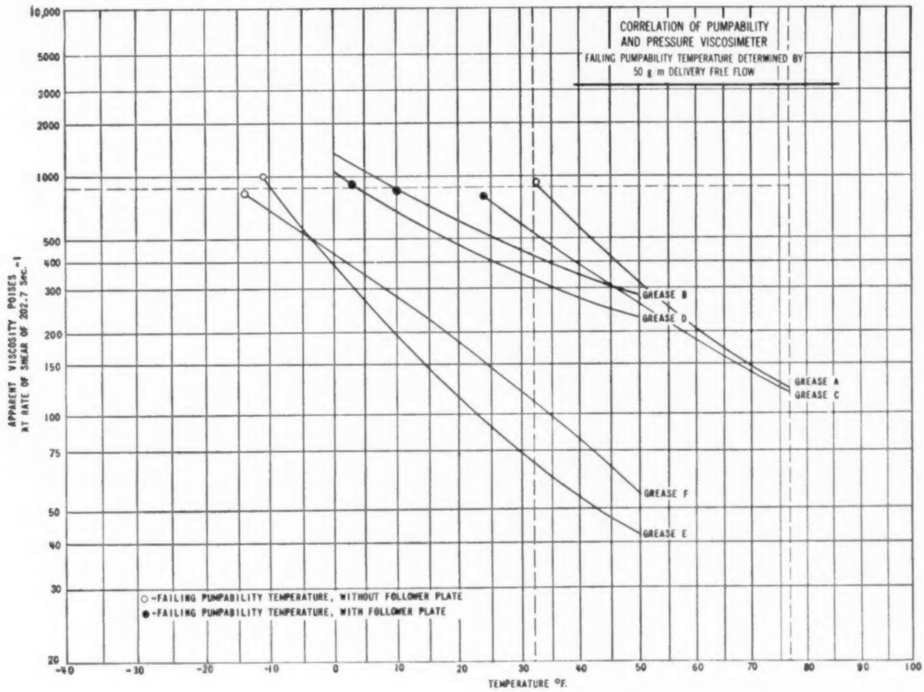


Figure 19 — Curves of apparent viscosity versus temperature.

lubricating system over a given temperature range. Obviously it is of advantage to know how readily any grease can be handled when planning the size (diameter) of the distributing lines, the maximum length possible, and whether or not jacketing or heating lines should be provided to insure proper flow in cold weather, as for example in lubricating outdoors such as on blast furnace charging machinery.

Pumpability data on any grease can be best obtained by laboratory study where operating conditions can be simulated and properly controlled. Some interesting information of this nature recently has been developed* using air operated industrial and service station type pumps as well as hand operated grease guns.

Air-Operated Test Equipment

Figure 14, page 105, shows the types of air operated pumps used. These pumps are designed to operate with a 100 pound grease cartridge and are equipped with a seven foot grease hose and a control valve. The air supply is furnished by a small air compressor similar to that found in service station

*At the Beacon, New York Research Laboratories of The Texas Co.

TABLE I

Grease	*Soap Base*	*Average % Soap*	*Average Viscosity Mineral Oil SUS*		*Average Dropping Point*	*Worked Penetration*
			100	*210*		
A	Soda	5.0		190	Semi-Fluid	370
B	Lime	16.0	310		210	235
C	Soda	11.0		95	400	280
D	Soda-Lime	13.0	315		290	280
E	Lime	8.5	280		200	370
F	Soda-Lime	10.3	287		315	374

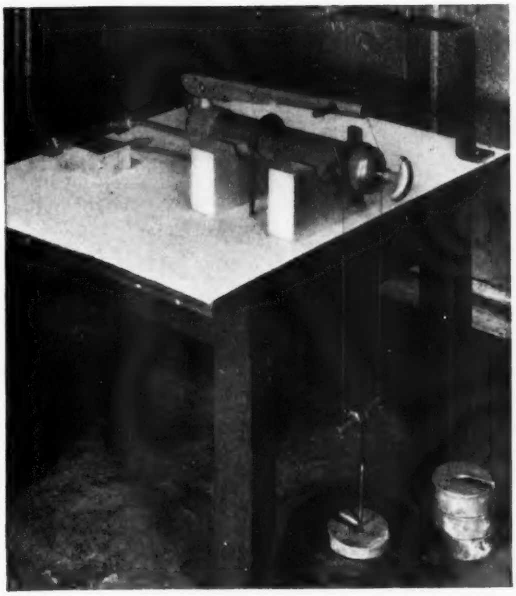


Figure 20 – Hand gun assembly.

TABLE II

FAILING TEMPERATURES (°F.)

Grease	*Hand Gun*	*Air-Operated Pump*
A	47	52
B	28	43*
C	42	36*
D	37	28*
E	0	24
F	11	5

*With Follower Plate.

TABLE III

FAILING TEMPERATURES IN CENTRALIZED LUBRICATION SYSTEM

Grease	*Temperature °F.*
A	0
C	0
D	8
F	–18

installations, operating with a 125 p.s.i. air supply pressure. In industrial applications an air supply pressure of 90 p.s.i. is typical, whereas in service station applications anywhere from 100 to 180 p.s.i air supply pressure may be found.

The operating mechanism of these pumps, as shown in Figure 15, p. 106, is briefly as follows: The air motor (2) actuated by the air pressure serves as the motivating force for the grease pump (6) located in the suction stub inside the grease cartridge. The grease feeds, or slumps, through the ports into the "primer" (8) by the force of gravity. On an upstroke of the gun the grease is picked up by the primer and lifted above the foot valve (7). On a subsequent downstroke of the gun, the foot valve is closed and the high pressure cylinder (6) forces down into the pocket of the grease and displaces the grease, creating the high grease pressure and delivery. As may be seen, the grease pump is a precisely designed unit whose operation principle is the same as that of a simple water lift pump.

Since these pumps are air-operated units, there are several items in the air system which may affect the performance and consequent delivery of the grease. For instance, the air motor ratio given by the manufacturers is significant in that with a 50:1 ratio, for every p.s.i. of air pressure supplied to the gun 50 p.s.i. of grease pressure is developed in the high pressure delivery hose. Thus, if sufficient delivery of a specific grease is not being obtained it may be possible to eliminate this difficulty by raising the air supply pressure, thus raising the grease pressure and, as a consequence, improving the delivery.

The condition of the air hose also may lead to insufficient delivery of grease; sometimes the interior may be rough and since most air hoses are made from rubber and have an outer and inner liner, it is possible for a pin point defect in the inner lining of the hose to occur. This small hole with the hose under pressure permits air pressure to act on the outside of the inner liner forcing it into the I.D. of the hose and causing a restriction. This restriction could easily result in an insufficient amount of air supply to the pump and consequently a reduction in the delivery of grease.

The Test Conditions

Delivery characteristics were tested not only under the optimum condition of free flow but also using adjustable shackles, as shown in Figure 16,

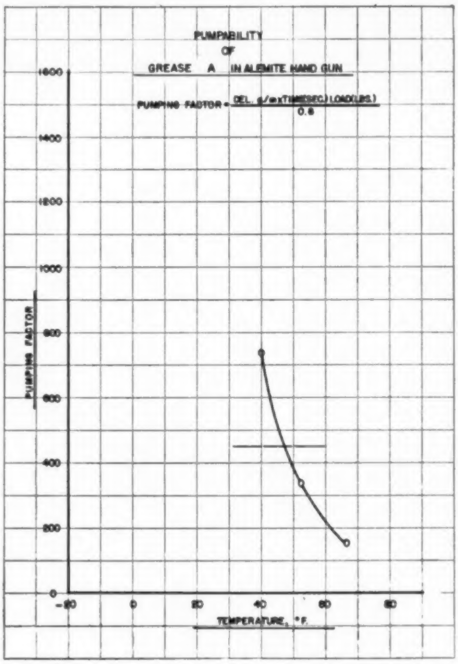


Figure 21 — Curve of data for hand gun.

p. 106, as typical restrictions. These adjustable shackles consist of a tapered sleeve with a tapered pin with the grease pumped through the side clearance. A loose or tight shackle is provided by the adjustment.

When the test equipment was assembled in a cold room, the temperature of the room was lowered progressively until a low delivery per minute of the grease was obtained.

The Test Results

The type of data obtained when running a typical NLGI No. 0 mixed base grease are shown in Figure 17, p. 107. Note the delivery characteristics of this grease under the three flow conditions. Because of the variable delivery, a definite point to determine the failing temperature is difficult to define. To develop an efficiency basis it was assumed that delivery at 70°F. indicates 100 per cent efficient operation. The temperatures for 70, 50, and 25 per cent of this amount were then determined. As may be seen with the aforesaid grease if the operator is willing to take twice as long to do a lubrication job, satisfactory operation would be obtained down to 49° F.

To set a single value of limiting delivery per minute is subject to personal opinion; however, for free flow conditions certain research authorities indicate a limited delivery of two ounces per minute and the CRC have arrived at 45 grams per minute as their limit. A compromise between these two figures of 50 grams per minute is fair in order to compare greases and also to conduct preliminary correlation work with the Pressure Viscosimeter which will be discussed below.

From an automotive point of view a second limit was arrived at by determining that four to five automobiles were lubricated on 453 grams of grease. Assuming that there is an average of 25 fittings per car, this would amount to 4.5 grams per fitting. With a further assumption that a man would allow 30 seconds per fitting, the round number of ten grams per minute for the grease in question was arrived at as the limit for a delivery through the loose adjustable shackle shown in Figure 16, p. 106. At the moment this shackle is considered as a typical restriction; further work as contemplated should determine where the restriction to flow through this shackle stands with respect to actual automotive fittings.

While the foregoing limits have been arbitrarily set it is still possible to select any basis of delivery per minute that is desired and from curves of test data the failing temperatures can be determined. Using the limits of 50 grams per minute for free flow conditions and ten grams per minute for delivery through the shackle the failing temperatures obtained are shown in Figure 18, p. 107.

One condition of pumpability which has not been mentioned is the possibility of the gun becoming air bound. For example several greases may pump satisfactorily through the accepted temperature range, then at a particular temperature the gun may become air-bound at which time grease delivery closes. Air binding depends upon the temperature and the amount of grease in the cartridge. It is considered as the "slumpability" limit of the grease, that is, the grease does not slump through the ports to the primer and as a consequence the gun pumps air. To overcome air-binding the use of a follower plate to help prime the grease will, in many cases, result in delivery of the product.

Correlation of Pumpability with the Pressure Viscosimeter

The testing of a grease in actual pumps not only

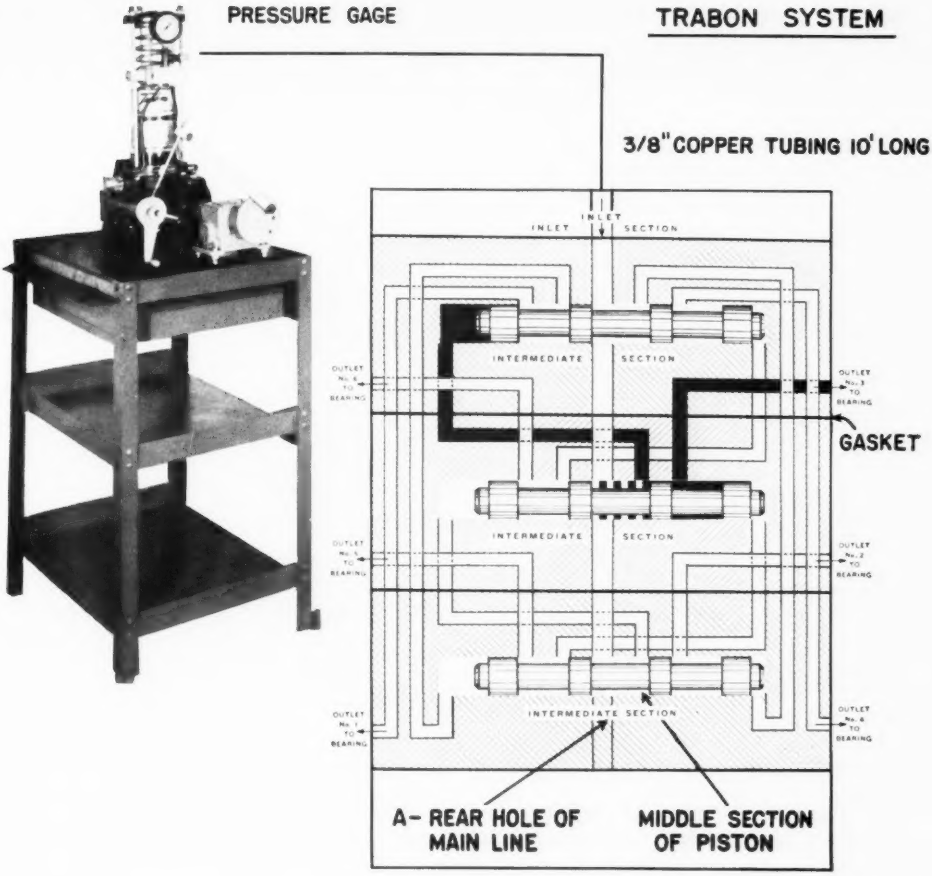


Figure 22 — Arrangement of Trabon Centralized Test Unit consisting of Trabon pump and header block. At left is shown entire pump assembly on test table. On the right is cross-sectional view of the header block.

requires a 100-pound cartridge of grease but also takes approximately three to four weeks to cover the temperature range. Studies have been made, therefore, to look into the possibility of obtaining a method to correlate pressure viscosimeter results with pumpability results. The curves illustrated in Figure 19, p. 108, represent data obtained in the pressure viscosimeter at a specific rate of shear (202.7 reciprocal seconds). Imposed on these curves as circles are the failing temperatures for 50 grams per minute delivery under free flow conditions for the respective greases as obtained from the pumpability data. These points fall around 900 poises as an average. Therefore, it appears that the failing temperature (based on 50 grams/minute free flow) of a grease may be approximated by testing in the pressure viscosimeter and determining the temperature at which a value of 900 poises is obtained.

The foregoing work, of course, is subject to additional studies and it may be possible to narrow the spread of the points about the average of 900 by the selection of another rate of shear. Further, the information obtained in such fashion will be relative for the various greases tested. However, it will indicate the relative pumpability characteristics of various products.

Hand Gun Test Equipment and Results

In pumping with a hand gun only one condition of flow was utilized, that is, through the loose adjustable shackle. To eliminate the human element in the operation of the lever gun, as may be seen from Figure 20, p. 109, a weight pan and weights are arranged to actuate the gun. The lever is raised to its uppermost position and allowed to fall and the

time for one stroke of the gun is determined and the amount of grease delivered is measured.

As the temperatures are progressively lowered a difference in the amount of grease delivered per stroke of the gun develops. This necessitated the utilization of a "pumping factor" to determine the pumpability of various greases in this unit. A typical result from the testing of a fibrous No. 0 chassis lubricant is indicated in Figure 21, p. 110, on which is shown a plot of "pumping factor" versus temperature. The formula to obtain the pumping factor is also shown in this Figure.

Over the test period to date, it has been found that 0.8 grams is the maximum amount of grease delivered per stroke of the gun used in the test. Accordingly it was assumed that, with optimum conditions a man would push on the gun for fifteen seconds and exert a force of 30 pounds. Substituting these values in the equation shown on Figure 21, p. 110, a pumping factor of 450 was determined. From this value, the failing temperature with this particular gun was obtained. The results obtained are shown in Table II, p. 109. For comparison purposes, utilizing the values obtained with the air-operated pump and delivery through the loose adjustable shackle with a failing delivery of ten grams per minute, the failing temperatures so determined are also shown.

Centralized Lubrication System and Results

The Trabon equipment as shown in Figure 22, p. 111, consists of a 5-pound grease reservoir from which the grease is positively displaced to the pump by a spring-loaded follower plate. From the pump the grease passes through 10 feet of copper tubing to the header block. The pressure required to force the grease through the copper tubing and through the header is measured by pressure gage. Prior to a test the complete unit is allowed to soak at the test temperature for 24 hours; following the soaking period the electric motor actuating the pumping unit is turned on and allowed to run for 8 hours. The maximum pressure and the amount of grease delivered during this period is recorded.

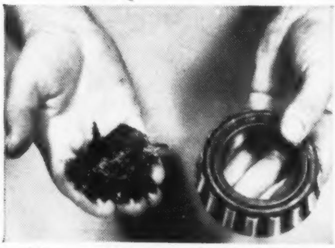
As the test temperatures are reduced the pressure required to force the grease through the tubing and header block increases until finally the safety disks mounted on the pump blow out, thus determining the failing temperature. The test results obtained to date are shown in Table No. III, p. 109. The temperatures indicated in this table are the temperatures at which the safety disks blow for the various greases tested.

CONCLUSION

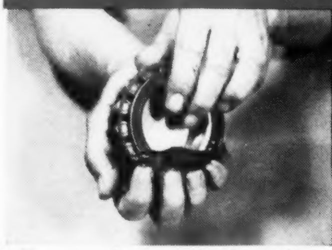
The manufacturers of grease lubricating equipment are to be commended for the part they have played in enabling the builders of machinery to attain present-day speeds and precision. From the humble grease cup which like Topsy, "just growed" they have perfected the systems of lubrication discussed in this article. To their ingenuity, along with the research activities of the petroleum chemist, is credited in large part the dependability with which grease-lubricated bearings and other machine parts are operating today.

Printed in U. S. A. by
Salley & Collins, Inc.
305 East 45th Street
New York 17, N. Y.

How to pack a wheel bearing and ... REDUCE MAINTENANCE COSTS with TEXACO MARFAK HEAVY DUTY



1. Place a *small amount of Texaco Marfak Heavy Duty* on fingers of one hand. Hold bearing (cleaned with kerosine, and thoroughly dried) as shown—small diameter facing out.



2. Turn bearing over (so large diameter faces out) into hand holding *Marfak Heavy Duty*. Work lubricant into spaces between rollers by kneading with fingers until it comes through on small diameter side.

3. Small diameter side of bearing, showing how *Marfak Heavy Duty* has been worked all the way through spaces between rollers. Repeat working-in operation around bearing until all spaces between rollers are packed.

4. All spaces between rollers have now been packed. Always work in steps, using small amount of *Marfak Heavy Duty* each time. Too much will cover bearing, prevent telling when grease is worked in properly.

5. Hold bearing as shown and spread additional *Marfak Heavy Duty* around the outside. Use enough to cover the tops of rollers with about 1/8-inch of lubricant. Spread evenly and smoothly.

6. Here is a bearing properly packed with *Texaco Marfak Heavy Duty*. Such a bearing will have full protection during the scheduled repacking intervals, plus many thousands of miles of additional bearing life.

TEXACO MARFAK HEAVY DUTY provides fluid lubrication inside wheel bearings but retains its original consistency at the edges. Thus, it seals itself in, seals out dirt and moisture, protects against rust. Safe braking is assured, and bearings last far longer. No seasonal change is required.

In chassis bearings, use *Texaco Marfak*. Even the roughest service won't pound or squeeze it out. It protects against wear and rust for extra hundreds of miles. Chassis parts last longer, maintenance costs are reduced.

Let a Texaco Lubrication Engineer help you reduce your automotive maintenance costs. Call the nearest of the more than 2,000 Texaco Wholesale Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, New York.

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